Quality of composts from municipal biodegradable waste of different origins

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QUALITY OF COMPOSTS FROM MUNICIPAL BIODEGRADABLE WASTE OF DIFFERENT ORIGINS

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SUMMARY: mechanical biological treatment of municipal solid waste is increasing rapidly in France as well as in other European countries. One of the outputs of this treatment is a compost prepared from the organic matter of the waste. This organic matter can be either collected selectively from the customers as biowaste, or separated from the total MSW in the plant. Unlike in Germany or Austria, where only the compost from selective collection of biowaste is allowed to serve as an amendment, in France the use of the compost is based on its compliance to a quality Standard. We present here the first results on an enquiry concerning the quality of composts from the two processes, determined on 5 French plants, between 2008 and now. All the composts fulfill to the prescriptions of the Standard and can be used as soil amendments.

1. INTRODUCTION

Biologic pretreatment of municipal waste: composting, anaerobic digestion (AD) is rapidly increasing nowadays in Europe and in France. Aims are the reduction and the stabilisation of landfilled waste to fulfill the Landfill Directive, the production of renewable energy (through AD), the valorisation of organic matter as a soil fertilizer. To be efficient, these biological treatments include a separation of the organic matter which undergoes the biological treatment. This separation can be done either by separate collection of biowaste, or sorting prior to the biological treatment in the treatment plant (mechanical biological treatment or MBT).

In France, there are now several installations of both types, composting and anaerobic digestion, with either separate collection of biowaste or mechanical sorting in the plant. Some intallations are only stabilizing waste prior to landfilling, but most of the plants produce composts which are used as soil amendments. For this use, the quality of the compost (e.g. agronomic quality and innocuity) must be assessed. The French standard NF U 44-051: 2006 (NF U 44-095 for composts from sewage sludges) describes both the agronomic quality (minimum carbon content, C/N ratio etc.) and the maximum values for a number of contaminant and inert compounds to which composts much comply before being used on fields. The French regulation states that all the values described by the standard shall be respected, nevertherless the origin of the compost (from separated biowaste collection or raw waste with optimized sorting).

INERIS has started an enquiry on the quality of composts from MBT and biological treatment plants, in order to evaluate the influence of a) the collective selection of biowaste or not, b) the pre-treatment, on the quality of the final product.

2. PARAMETERS FOR THE QUALITY OF COMPOSTS

The composts which are put onto the market in France must comply with the French standard on the quality for organic amendments, NFU 44051. This standard specifies the waste which are allowed for composting, the agronomic parameters, limit values for contaminants (with a maximum flux on soils per 10 years period for metals and organic trace compounds) and microbiology. Compliance with this standard is mandatory for use on soil. Limit values are completed for some parameters by maximum fluxes per 10 years period, in g/ha (ha: surface unit, one “hectare”: 10,000 square meters). Prescribed values for the different parameters are given in Table 1 to 5.

Table 1. Agronomic parameters prescribed by the French Standard NFU 44051 for composts.

Parameter	Dry matter	Organic matter	N**	P_2O_5**	K_2O**	Σ (N + P + K)	C/N ratio
Limit value	> 30 % of total matter	< 15 to 25 % of total matter*	< 1 %	< 1 %	< 1 %	< 7 %	> 8

** this value depends on the category of compost, 20 % for composts from organic matter of municipal waste*

*** otherwise the compost is sold as “amendment with fertilizer”*

Table 2. Limit values for heavy metals prescribed by the French Standard NF U 44051 (content and flux to the soil).

Metal	As	Cd	Cr	Hg	Ni	Pb	Se	Cu	Zn
Limit value, mg/kg DM*	18	3	120	2	60	180	12	300	600
Limit value, mg/kg OM**								600	1,200
Max flux per 10 years, g/ha***	900	150	6,000	100	3,000	9,000	600	10,000	30,000
Max flux per year, g/ha	270	45	1,800	30	900	2,700	180	3,000	6,000

** DM: dry matter*

*** OM: organic matter*

**** ha: hectare (1 ha = 10,000 m^2)*

Table 3. Limit values for inert materials and impurities prescribed by the French Standard NF U 44051.

Inert materials and impurities	Films + PSE** > 5 mm	Other plastics > 5 mm	Glass + metal pieces > 2 mm
Limit values, % DM*	< 0.3	< 0.8	< 2.0

** DM: dry matter*

*** PSE: expanded* polystyrene

Table 4. Maximum flux per 10 years and limit values for Organic Trace Compounds (O. T. C.) prescribed by the French Standard NF U 44051.

O. T. C.	Fluoranthene	Benzo-b-fluoranthene	Benzo-a-pyrene
Maximum flux, g/ha/year*	6	4	2
Limit value, mg/kg DM**	4	2.5	1.5

** ha: hectare*
*** DM: dry matter*

Table 5. Limit values for pathogens prescribed by the French Standard NF U 44051.

Pathogen	All cultures except market gardening	Market gardening
Viable Helminth eggs	Lack in 1.5 g	Lack in 1.5 g
Salmonella	Lack in 1 g	Lack in 25 g

3. ORIGINS OF THE COMPOSTS

Composts on which the quality and contaminants content are discussed come from 5 French plants, representative of the different technologies which are presently operational. All the composts studied are prepared from the biodegradable fraction of municipal solid waste. Four of the composts come from an anaerobic digestion (AD) of the organic fraction of the waste; the last one was directly prepared by aerobic degradation (composting) of the organic matter, after the sorting of the waste. Two sites (with AD) treat organic fraction with a selective collection of biowaste, green waste and oils from food manufacturing, the 3 other sites treat municipal waste collected mixed, the organic fraction is sorted within the plant. All composts from these 5 sites comply with the standard NF U 44-051.

Processes are:

- **Plant A**: **anaerobic digestion of biowaste collected separately**, mixed with municipal green waste, garden waste, food waste; no preparation before anaerobic digestion (thermophilic, 25 days); post-treatment comprises an active composting step in tunnels (3 weeks), a sorting and a maturation step (another 3 weeks) in an open building.

Analytical results cover the year 2010 (12 analysis) and are reported as “Site A”.

- **Plant B**: **anaerobic digestion of biowaste collected separately**, mixed with municipal green waste, garden waste, food waste (cooking grease), paper and cardboard collected in the urban area; no preparation before anaerobic digestion (thermophilic, 3 weeks); post-treatment comprises drying (36 hours), active composting 15 days, passive composting 15 days. The compost is sieved at 12 mm.

Analysis are performed on a quaterly basis; 10 analytical sets are available over 2009-2010; they are reported here as “Site B”.

- **Plant C: anaerobic digestion of MSW**, following a separated collection of recyclables. There is no crushing of the raw waste; the first step is a pre-biological degradation in a rotating tube (3 days) in which garbage bags are opened. During this step, paper and carboard are reduced to small pieces. This step is followed by several separation steps. The smaller fraction (smaller than 10 mm, composed to more than 95% of organic matter) is introduced in the digestors for 1 month. The digestate is then dried, mixed with wood, and sent to the composting plant for 2 weeks of active composting (2 weeks with forced aeration and returns). The compost is then kept for 1 month of maturation. Analyses are performed each month (e.g. on each lot of compost).

Analytical results were available for 2 years (2009-2010), giving a 24-values set. They are reported here as “Site C”.

- **Plant D**: **anaerobic digestion of MSW**, following a separated collection of recyclables. A crushing of the raw waste is performed as a first step. The crushed matter undergoes anaerobic digestion for 3 weeks. The digestate is pressed, and then filtered. The solid fraction of the filtering step goes to composting, mixed with wood pieces to structure the compost. Composting is performed outside of the plant.

Analysis are performed on a 6 months basis, since March 2010. 2 to 4 results (depending on the parameter) were available. They are reported as “Site D”.

- **Plant E: composting process on MSW** (with a separated collection of recyclables); no crushing; first biological step in a rotating tube (3-4 days); several separation steps; the smaller fraction (smaller than 10 mm) is sent to a composting hall and deposited in windrows. Windrows are turned with an automatic turner twice a week (1 month); compost is then matured for 2-3 months.

Analysis are performed on a more or less quaterly basis (except for trace organic compounds, once or twice a year). A set of 12 results cover 2009-2011. They are reported as “Site E”.

4. RESULTS: AGRONOMIC QUALITY AND CONTAMINANTS

4.1 Agronomic quality

Although the contaminants are the major problem which could arise from the use of composts from organic municipal waste, these products are sold as amendments.

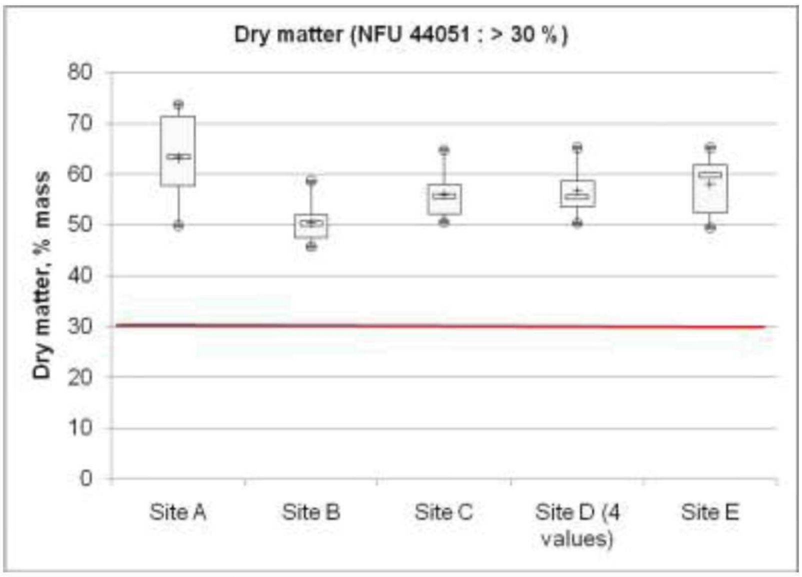

Figure 1. dry matter content of the 5 composts.

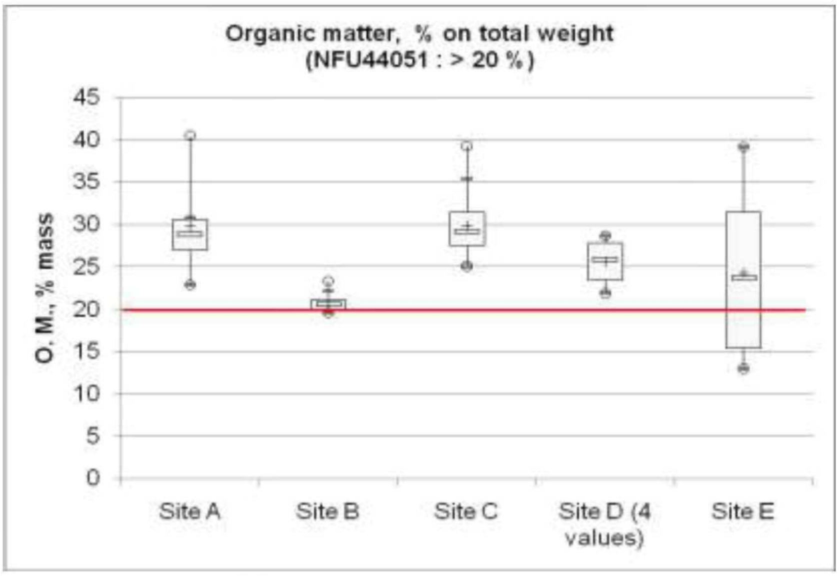

Figure 2. organic matter content of the 5 composts.

Therefore, in order to be valorized, they must comply with agronomic qualities of amendments, prescribed as dry matter content, organic matter content etc. Figures 1 to 4 plot all the available results for the 5 composts. The limit values prescribed by the Standard for each parameter are reported on the graphs when possible.

- All composts content enough dry matter: from 50 to 70 % in weight, while the prescription of the Standard is at least 30 % (see Figure 1). The two composts obtained from the selective collection of biowaste show the more scattered results; the dry matter contents of composts from organic matter of MSW (OMMSW) are closer: 55 to 60 %.
- The organic matter contents of the composts are more scattered than the dry matter contents: see Figure 2. One of the composts from the selective collection of biowaste has a content of 20 % (on total weight), which is the minimum value prescribed by the standard. The compost from site E (OMMSW without anaerobic digestion) show scattered values. On this site, organic matter content of the compost was low until early 2010. Since then, the process has changed a little, and the organic content rose up to between 27 and 39 %.
- All the composts have a C/N ratio which fulfills the Standard (> 8): see Figure 3. Values are scattered from 8 to 20. There is no evidence that the selective collection of biowaste give better results for this criterion.
- The sums of the fertilizing compounds (nitrogen, phosphorus and potassium) fall well below the maximum value of 7 % for all the composts, as shown on Figure 4 (the limit value is not represented on the graph as it falls well above the values for 4 composts). This parameter was not determined for Site D and is therefore not reported. Once again, there is no obvious difference between composts from selective collection of biowaste and OMMSW.

As a summary, after optimization of the process (e. G. Site E), all the composts fulfill the agronomic specifications stated by the French Standard to be considered as organic amendments, with no obvious difference due to the collection or treatment processes.

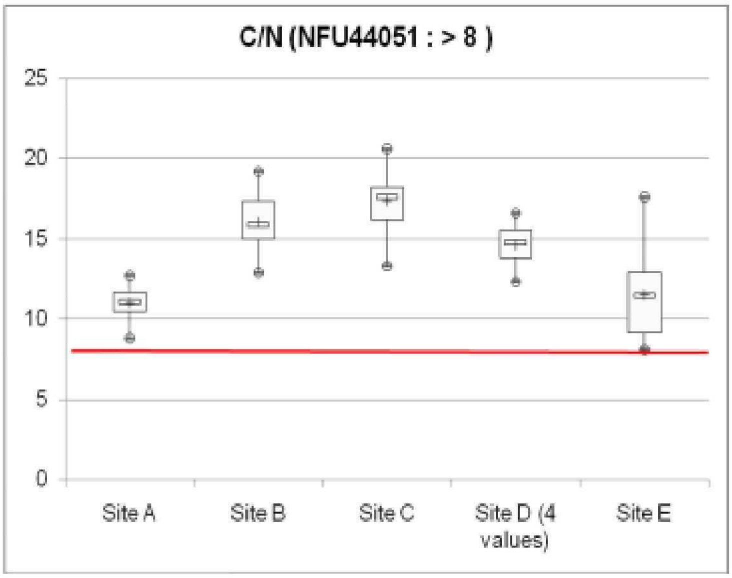

Figure 3. C/N ratio of the 5 composts.

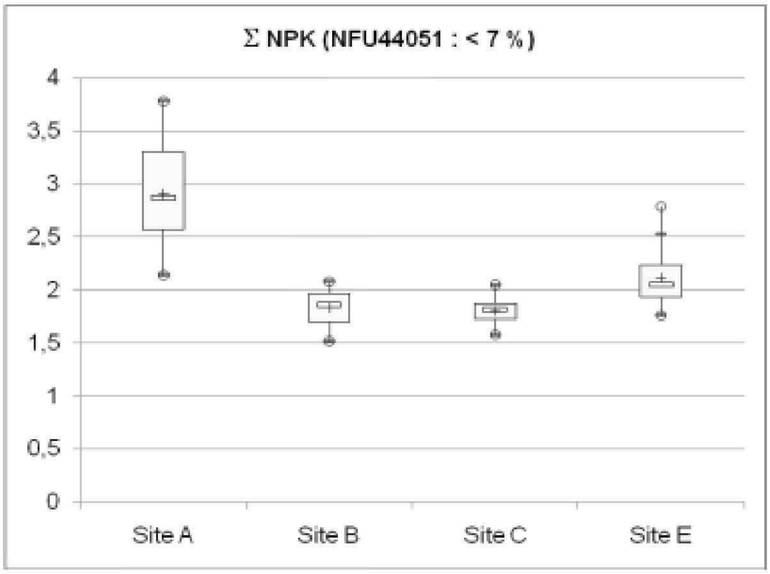

Figure 4. Sum of fertilizers of the 5 composts.

4.2 Contaminants and impurities

As we have seen in paragraph 2, the French Standard NFU 44051 prescribes limit values for several inorganic, organic and biological contaminants, as well as for impurities. These parameters are discussed here.

4.2.1 Inerts (plastics, glass and metal pieces)

Figures 5 to 7 represent the impurities contents of the 5 composts. Limit values are shown on the graphs for each parameter.

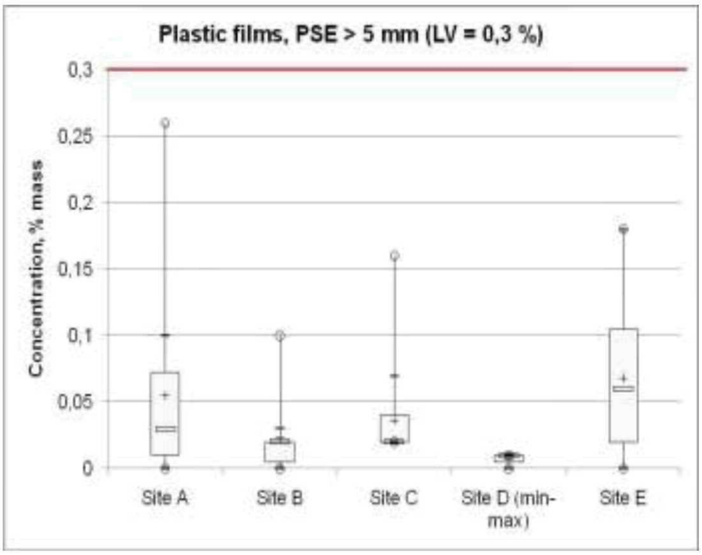

Figure 5. Films and PSE content of the 5 composts.

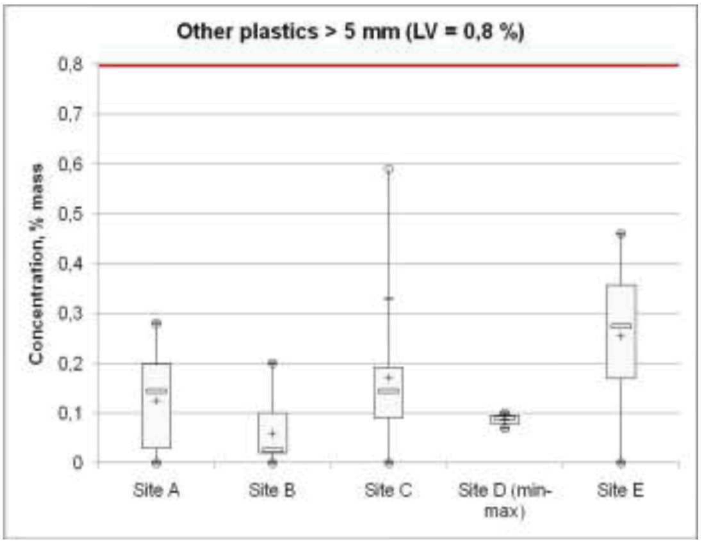

Figure 6. Other plastics content of the 5 composts.*

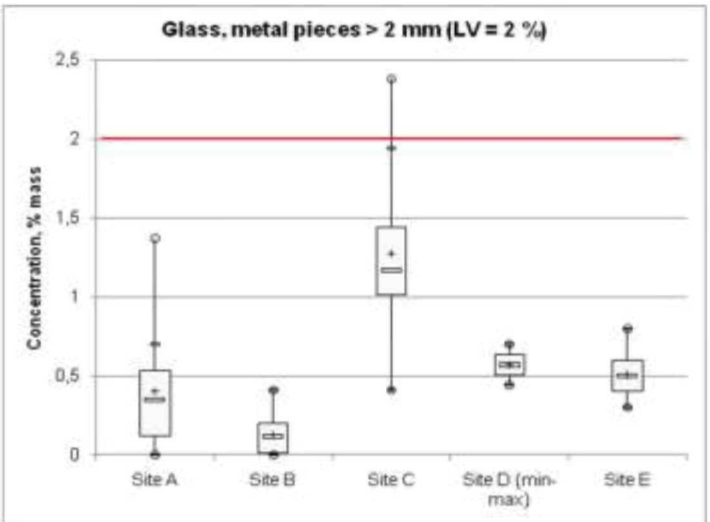

Figure 7. Glass and metal pieces content of the 5 composts.

- All the composts fulfil the limit values stated by the Standard for plastics (either films, polystyrene or other plastics, see figures 5 and 6). Surprisingly, the compost from site D, where total MSW is crushed before entering the digestor, presents the lower content for plastics. This comes from the fact that the digestate is pressed; the liquid fraction of the pressing process is then filtered. The solid residue of the pressing process contains all the "large" impurities (bigger than 2 mm) and is discarded. Only the solid part of the filtering process undergoes the composting process (the liquid fraction is reinjected in the process). This solid fraction contains very few large particles.
- All the composts nearly fulfil the Standard limit value for inert materials (glass and metal pieces larger than 5 mm). There are only 2 analytical values (out of 24) for the compost from site C which slightly exceed this value. These analyses were done in 2009 and 2010. At the beginning of 2011, the city which sends its waste to site C set a separate collection for glass, door-to-door, for all the customers. It is expected that the glass content of the compost should be lowered and could then always fulfil the criteria of the Standard.

4.2.2 Heavy metals

Analytical results for heavy metals are numerous and therefore are not represented by graphs. Table 6 presents the mean values for all the metals cited by the Standard, for the 5 composts. The higher value for each compound is bolded.

For all the composts, heavy metal contents are well below the limit values: the mean values are half of the limit value or less. Maximum values for all the composts are not presented here, but there is no value exceeding the limit values, for each metal, over the 60 analysis.

Table 6. Heavy metal content of the 5 composts, mean values, compared to the limit values (NFU 44051).

Metal	As	Cd	Cr	Hg	Ni	Pb	Se	Cu	Zn
Limit value, mg/kg DM*	18	3	120	2	60	180	12	300	600
Mean value, site A	4.17	0.75	27.51	0.13	17.76	83.6	2.63	49.67	248.1
Mean value, site B	3.51	0.53	24.98	0.12	16.18	61.9	1.91	74.73	229.9
Mean value, site C	3.06	0.99	44.27	0.49	24.01	98.6	0.57	90.11	297.6
Mean value, site D	1.49	0.80	35.19	0.32	14.02	118.7	0.88	75.87	243.3
Mean value, site E	3.12	0.44	24.78	0.24	15.19	44.6	0.63	80.07	239.7

* DM: dry matter

4.2.3 Trace organic compounds

Figures 8 to 10 represent the analytical data for the trace organic compounds.

As for the metals, all the data gathered for all the composts fall well below the limit values for the 3 compounds. It should be noticed that, except for the compost of site E, for which the quantification limit on BbF and BaP are 0.5 mg/kg, the composts from the OMMSW present a lower organic content than the composts from selective collection of biowaste.

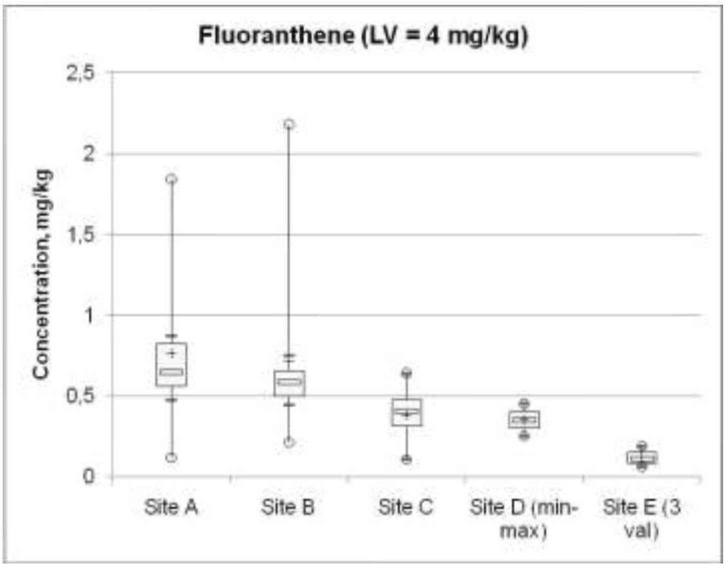

Figure 8. Fluoranthene content of the 5 composts.

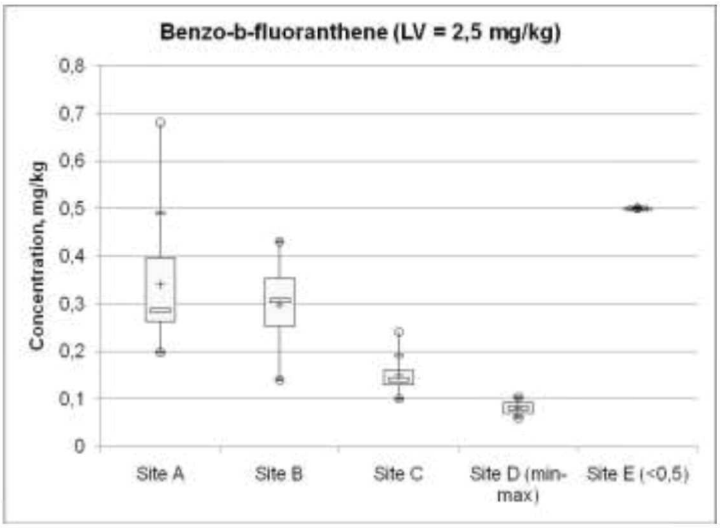

Figure 9. B-b-fluoranthene (BbF) of the 5 composts.

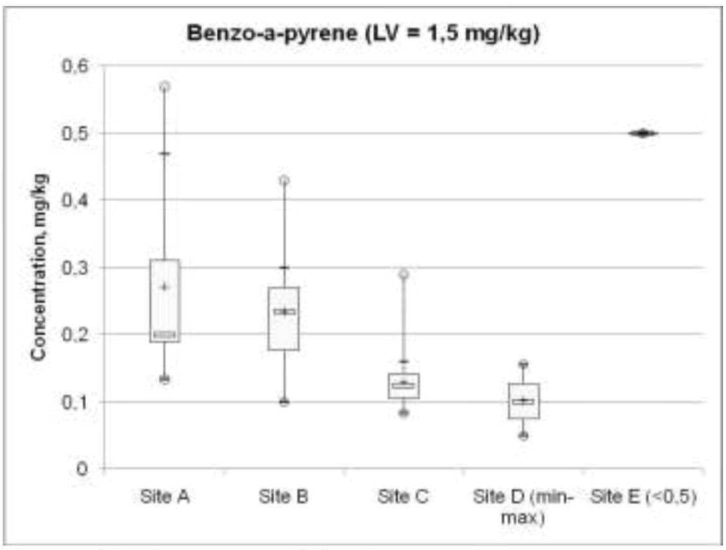

Figure 10. Benzo-a-pyrene (BaP) content of the 5 composts.

4.2.4 Microbiology

All the analytical results for all the samples, for which we received analytical data, showed a lack of both viable Helminth eggs and *Salmonella* in respectively 1.5 and 1 g of the samples. Thus, these composts are correctly hygienized by the processes and can be used as amendments in cultures without biological contamination problems.

5. CONCLUSIONS

As MBT plants quickly develop in France, there are questions on the quality of composts from the organic fraction of MSW as soil amendments. The present study gives first responses to those questions.

There is no obvious difference from composts produced by biological plants which receive biowaste collected separately, and composts originated from MBT plants (either aerobic or anaerobic). A specific analysis done with transmission electronic microscopy (not discussed here) shows that compost from anaerobic digestion is more stabilized than the one produced by a simple composting process. This is due to the anaerobic digestion, which lasts 1 month in this case. Therefore, the disponibility of the nutritive elements differ and should be taken into account in the amendment plan. Nevertherless, both these composts have a good agronomic quality, and a low contaminant content, which makes them suitable for all agricultural crops. As a matter of fact, they are well apreciated by the local farmers.

These compost qualities make a real improvement for the use of the MBT. These sustainable and local productions of organic matter of good quality should be more widely proposed. The quality of the MSW compost must compete with other source of organic matter. The only drawback is the need to make a study for the possible use of compost at the local scale, in order to maximize the benefits of that treatment.

The results of the present study complete the data sets gathered by other French Institutes (ADEME, AFNOR), and will participate to a European study on the quality of composts from different origins, launched by the Joint Research Centre (Seville) in May 2011.

ACKNOWLEDGEMENTS

The Authors wish to thank the plant operators for providing the analytical results. This study is funded by the French Ministry of Ecology and Sustainable Development.

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